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Sabrina Reyes, a 2nd grader at East San Jose Elementary School, investigates the effect of airstream on a group of pinwheels during Family Science Night at Explora, a science center in Albuquerque, N.M. Explora regularly hosts the event to promote informal science learning for area students and their families.

WEB EXCLUSIVES
For more on informal science education:

- Read Staff Writer Sarah D. Sparks’ story that delves into the growing world of online communities where science is the topic and see videos of the science experiments she writes about. www.edweek.org/go/Experiments
- Then, join an online forum to post your favorite videos of experiments and share how you use these videos in the classroom. www.edweek.org/go/ExperimentsForum
- View a photo gallery of the Explora science center. www.edweek.org/go/Explora
- Join Assistant Editor Erik W. Robelen and guests for a free Webinar on the evolving field of informal science education—what we know about its impact, what it looks like in practice, the potential, and the challenges.

PRESENTERS
John H. Falk, professor of free-choice learning at Oregon State University and founder and director emeritus of the Institute for Learning Innovation Alan J. Friedman, former director and CEO of the New York Hall of Science, consultant in museum development and science communication, and member of the National Assessment Governing Board

Date: Tuesday, April 19, from 2 to 3 p.m. EDT
www.edweek.org/go/webinar/learningScience
When a fresh round of national and international data on student achievement in science came out recently, the results—widely seen as disappointing—prompted familiar hand-wringing from political leaders and education experts about the steps needed to improve science instruction in the public schools.

What’s often missing from the national dialogue on the issue is a concerted focus not simply on what happens in the classroom, but also on the opportunities to learn about science—and to inspire a passion for the subject—that come outside the school day and the formal curriculum.

But many leaders in the field often referred to as “informal science education” say that is beginning to change. There are signs that this sector is garnering wider attention and starting to be included in broader discussions on how to improve science learning among young people.

David A. Ucko, a former senior official at the National Science Foundation, said the field now has greater external recognition of its impact on public awareness, understanding, and engagement with science and related subjects. “There is definitely momentum building,” agreed John H. Falk, a professor of free-choice learning at Oregon State University, in Corvallis. “The good news is that the field is of late being invited to some tables and being taken seriously as important, but it’s still roughly an order of magnitude less than formal education.”

One boost to the cause was the 2009 release of a major National Research Council report, “Learning Science in Informal Environments.” With the prestige of the National Academies behind it, the document served as a clarion call. “Efforts to enhance scientific capacity typically target schools and focus on such strategies as improving science curriculum and teacher training and strengthening the science pipeline,” the report said. “What is often overlooked or underestimated is the potential for science learning in nonschool settings, where people actually spend the majority of their time. “Beyond the schoolhouse door,” it said, “opportunities for science learning abound.” Indeed, they do. Visits to science-rich cultural institutions, such as zoos, aquariums, science centers, and natural-history museums immediately come to mind. But it’s really a host of opportunities. Astronomy and robotics clubs. After-school programs and science competitions. Collecting rocks or taking a walk in the woods. Watching television programs such as “MythBusters” or turning to the Internet to learn more about cancer or global warming. The list goes on and on.

President Barack Obama, who has aggressively used his bully pulpit to promote education in the STEM fields of science, technology, engineering, and mathematics, seems to awareness grows of importance of learning Science Beyond School

BY ERIK W. ROBELEN

When a fresh round of national and international data on student achievement in science came out recently, the results—widely seen as disappointing—prompted familiar hand-wringing from political leaders and education experts about the steps needed to improve science instruction in the public schools.

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President Barack Obama, who has aggressively used his bully pulpit to promote education in the STEM fields of science, technology, engineering, and mathematics, seems to

BY SARAH D. SPARKS

In one of the best-remembered TV science experiments, Donald J. Herbert, aka Mr. Wizard, and one of his student-helpers peered over a waist-high acrylic box filled with set mousetraps, representing fissile material in an atomic bomb. On each perched a pingpong ball, representing the neutrons. When one additional ball dropped into the mix, the entire box went up in an explosion of white plastic.

When Mr. Herbert died in 2007, after more than a half-century in educational entertainment, science television shows had exploded more fully than his ping-pong balls. The National Research Council’s 2009 landmark study of informal science highlighted evidence that children’s shows such as “Bill Nye the Science Guy” can increase not just students’ interest in science, but also their understanding of complex scientific concepts. Here’s a look at some of the top science television series through the years.

Watch Mr. Wizard (1951)

The granddaddy of all children’s science shows, “Mr. Wizard” first aired on WMAQ, Chicago’s NBC station. It spanned more than 600 shows during the 1950s and ’60s, and another 78 shows, as the cable-based “Mr. Wizard’s World,” in the 1980s and ’90s, according to Tom Nikosey, the president of Mr. Wizard Studios in West Hills, Calif.

Science Through the TV Screen

Photos by AP Except Where Indicated

Opportunities are plentiful, from afterschool programs to computer simulations to visiting a zoo.

Education Week: Science Learning Outside the Classroom • www.edweek.org/go/ScienceReport • April 6, 2011
NO TESTS OR GRADES

In an increasingly data-obsessed education landscape, one challenge is meeting the demand for concrete evidence on how individuals benefit from informal learning opportunities.

The NRc report found “abundant evidence” that people of all ages learn science across a wide range of venues and activities. But that report, and interviews with experts in the field, suggest there’s still a long way to go in better evaluating and understanding the impact.

Advocates for informal learning emphasize that it’s vital not simply to align measures for out-of-school learning with the focus on standardized achievement tests so prevalent in public education.

Instead, the idea is to gauge scientific skills and understanding in ways that are more appropriate to the various settings and activities, as well as to look at interest in science topics and a person’s self-identification as someone knowledgeable about science.

If we allow the things that are easy to measure in school districts as the only definitions of learning we’re going to consider, we are leaving off the table an awful lot of things,” said Kevin J. Crowley, the director of the University of Pittsburgh’s Center for Learning in Out-of-School Environments and an associate professor of education and psychology. “We need to have compelling, theory-based, reliable measures, and we’re just beginning to chip away at that right now.”

The NRc report said one important feature of informal learning settings is the absence of tests, grades, and other familiar approaches used by schools to document the effect of education.

“Assessments should not be limited to factual recall or other narrow cognitive measures of learning,” it said, but instead “should address the range of intellectual, attitudinal, behavioral, social, and participatory capabilities that informal environments effectively promote.”

In fact, tools are now emerging that show the potential to link individuals’ learning across a lifetime of different experiences. (See Story, Page S6.)

One domain that is seeing a strong push to promote learning and engagement in science is the after-school setting. In fact, 2011 was billed as the “Year of Science after-School” by several leading groups, including the Afterschool Alliance, the National AfterSchool Association, and the National Summer Learning Association.

“We’re all speaking with one voice to say this is important,” said Anita Krishnamurthi, the director of STEM policy for the Afterschool Alliance, an advocacy group based in Washington.

Meanwhile, initiatives have recently emerged in California and Missouri to establish sustainable statewide systems that support and promote high-quality after-school programming in the STEM fields. The initiative in Missouri, Project Liftoff, is working to spark similar undertakings in other Midwestern states as well. Among the efforts planned are identifying a menu of first-rate curricular materials in the STEM fields, better preparing after-school program staff members to provide engaging STEM activities, and supporting the evaluation and improvement of such after-school offerings.

The project is getting financial backing from the Noyce Foundation, which also underwrote this report’s expenses. In February, for instance, the Howard Hughes Medical Institute, based in Chevy Chase, Md., announced the launch of a $60 million documentary-film initiative to bring compelling science features to television.

Further, new technologies hold tremendous promise to advance science learning and interest, with the advent of increasingly sophisticated computer games and simulations, among other developments. (See story, Page S12.)

‘URBAN ADVANTAGE’

Ensuring access across the U.S. population, especially among low-income and minority families, is seen as an important goal for many informal initiatives and institutions, from after-school programs to science centers and museums, such as Explora, in Albuquerque, N.M. Explora offers free memberships for low-income families and hosts Family Science Nights in partnership with the city school district as a way to better acquaint such families with its offerings. (See story, Page S6.)

The Family Science Night idea also illustrates another theme: the value of fostering direct connections between schools and informal learning environments. Around the country, there’s no shortage of such collaborations.

Explora, like many other science centers, also offers professional-development programs for teachers. And it offers a menu of more than 200 hourlong experiential programs for students, called “explorations,” pegged to the state’s academic standards.

In New York City, Urban Advancement, a program led by the American Museum of Natural History, has brought together the city school system and an assortment of science-rich institutions, including the New York Hall of Science.
COSMOS: A PERSONAL VOYAGE (1980)
The internationally renowned astrophysicist Carl Sagan presented and co-wrote both this 13-episode series and an accompanying book, which PBS first aired. According to its website, it remains the most popular PBS series in the world.

THE CROCODILE HUNTER (1997)
This wildlife documentary hosted by the exuberant Australian naturalist and zoo owner Steve Irwin proved a breakout hit for the cable channel Animal Planet in more than 130 countries before Mr. Irwin was killed in 2006. It spun off several specials and a children’s program, “Bindi, The Jungle Girl,” hosted by Mr. Irwin’s school-age daughter.

BILL NYE THE SCIENCE GUY (1993)
KING-TV, Seattle’s NBC affiliate, first aired the show by the Cornell University engineer while he was moonlighting as a stand-up comic, according to his biography site. The show won 18 Emmys in its five years on air and has spun off several science shows, such as the Science Channel’s “100 Greatest Discoveries,” “The Eyes of Nye” on PBS, and Planet Green’s “Stuff Happens.”

MYTHBUSTERS (2003)
The Discovery Channel launched this series, hosted by two Hollywood special-effects designers and their assistants, who test urban legends, Internet rumors, and historical myths through experiments. In 2009, President Barack Obama asked the team to re-create (and eventually bust) the legend that the ancient Greek Archimedes used a “solar death ray” of mirrors to ignite invading ships in 212 B.C.

LIFELONG LEARNING
A relatively small percentage of waking hours across the life span are spent in formal educational environments.

9.25%

Formal Learning Environments
Informal Learning Environments

18 WAKING HOURS

18.5% 7.7% 5.1%

Ages 0-5 Kindergarten Grades 1-12 Undergraduates Postgraduates Workers Retirees

SOURCE: Learning in Informal and Formal Environments Center
Oregon State University, along with many other institutions, faces a barrier to expanding its role. Insufficient money remains a big issue, people who know the field say. Yet, even as the economic stimulus legislation enacted in 2009 included a short list of institutions barred from receiving funds not only casinos, golf courses, and swimming pools, but also zoos and aquariums. (The Senate-passed bill sought to add museums, theaters, and several other categories to the list, but that language was removed.)

“Despite scores of such examples, informal learning remains a big barrier to expanding its role,” it said. “The walls between formal and informal learning professional fields are only beginning to crumble. There is too little transfer of practice, learning, and community.”

“A MODEST CHANGE”

Even as informal science education is gaining more prominence, people who know the field say insufficient money remains a big barrier to expanding its role. In a recent essay, Mr. Falk from Oregon State University, along with Lynn D. Dierking, also a professor of free-choice learning at that university, noted that far more funding goes to public schooling in science than informal learning opportunities.

“Even a modest change in this ratio could make a huge difference” to Americans’ science literacy, they wrote in the December issue of American Scientist magazine, though they emphasized that they were not suggesting lessening support to schools.

Martin Storksdieck, the director of the Board on Science Education at the National Academies, suggests that advocates still have a lot of work to do in convincing policymakers and the public that informal science learning merits increased investment.

He points to a telling illustration. The federal economic-stimulus legislation enacted in 2009 included a short list of institutions barred from receiving funds not only casinos, golf courses, and swimming pools, but also zoos and aquariums. (The Senate-passed bill sought to add museums, theaters, and several other categories to the list, but that language was removed.)

“At the end of the day, we haven’t made the value proposition in the political arena or to consumers as much as we should,” Mr. Storksdieck said, “of just how fundamentally beneficial these learning spaces are, and how much we as a society and as individuals benefit when we take part in what they have to offer us.”
Researchers Playing Catch-Up
In Gauging Beyond-School Effects

BY SARAH D. SPARKS

Emerging research shows the science-school-age learn in informal settings—from museums and clubs to online communities and television shows—can have a big impact on their lives. Yet the open format and distinct structures of informal science make it next to impossible for researchers to evaluate the quality of those experiences in the same way they can gauge formal schooling.

School assessments generally focus on cognitive measures, such as what a student knows and can demonstrate about particular content. In contrast, informal learning is dominated by noncognitive measures such as motivation, interest, and identity, according to Larry E. Suter, the National Science Foundation’s program director for informal science education. Moreover, traditional “gold standard” research methods such as randomized controlled trials can be detrimental to activities that base their strength on people’s choosing to participate, rather than being assigned.

Such research raises the risk, Mr. Suter said, that “if you touch it, you’re going to kill that thing you’re trying to study.” That has led to some creative research alternatives. Alan J. Friedman, a former director and chief executive officer of the New York Hall of Science and the editor of the NSF’s 2008 framework for evaluating informal science education, recalls judging the effectiveness of an astronomy exhibit by the number of visitors who chose an astronomy poster over a different prize. Barbara N. Flagg, the director of the Multimedia Research consultant group in Bellport, N.Y., said she has used smudged museum walls indicating where visitors have touched exhibits, changes in Google and Amazon search terms over time, and phone interviews with parents and children.

“If you’re comparing this to other education research, you’ve got to turn back the clock 30 or 40 years,” said Kevin J. Crowley, the director of the University of Pittsburgh’s Center for Learning in Out-of-School Environments and an associate professor of education and psychology. “We are just now in the Wild West frontier, and people are just starting to gear up the longitudinal studies on how this will coalesce into a coherent narrative of how people learn science.”

Now, the tools being born of that creativity show the potential to link children’s education across a lifetime of different experiences, and in the process uncover more of how and what children learn than has ever been measured in a school test alone. Children, after all, spend more than 80 percent of their waking hours outside the classroom.

“The research has evolved,” Mr. Crowley said. “In the past, the great flaw of the informal-learning science was what we looked at in situ scientific achievements or level of interest in the subject. Teachers reported the first-generation Hairson the 14th-grader across formal and informal settings for more than 2,000 hours, they knew that school didn’t tell Brenda’s whole story. Not only did she regularly measure and mix chemicals and record the results for her perfume-making hobby, but she also had told the researchers she was considering becoming a chemist when she grew up.

“School science underrepresents laboratory and the director of ethnographic Group there, said during a recent lecture. “Just in terms of how people learn, our literatures don’t do justice to the varied pathways that people take through their experiences to make progress on things they care about.”

INTEREST VS. GRADES

That’s a dangerous disconnect, experts say, because mounting evidence shows that early engagement, even through informal pathways, eventually can lead to careers in the STEM fields of science, technology, engineering, and mathematics more surely than top grades in school.

In a 2006 study published in the journal Science, Robert H. Tai, an associate professor at the University of Virginia’s Curry School of Education, in Charlottesville, tracked thousands of students via the National Educational Longitudinal Study. He found that students who had only average grades in middle school but expressed interest in science were two to three times more likely to earn bachelor’s degrees in a science or engineering field 12 years later than high-achieving students who did not voice interest.

The landmark 2009 study that Mr. Bell co-wrote, “Learning Sci-

What’s measured in the classroom—what students know and can do—differs from what’s currently measured outside—such as motivation and interest.

VITAL LINKS


This landmark study by the National Academies’ Committee on Learning Science in Informal Environments documented evidence that children and adults do learn science outside of direct school instruction. Both designed science settings such as zoos or museums and spontaneous settings such as a walk in the park can help children understand science. The book laid the foundation for a more evidence-based approach to informal science education.

Surrounded by Science: Learning Science in Informal Environments (2010)

Based on an NSF workshop on informal science education, this framework lays out the criteria for measuring informal science, based on a participant’s awareness, knowledge, or understanding of a science topic; engagement or interest in science; attitude toward science or careers in the field; changes in scientific behavior such as inquiry; and the improvement of specific skills related to science, such as experimenting or data analysis.

Measuring the Impact of a Science Center on Its Community (2011)


By studying Los Angeles residents and museum-goers before and a decade after a massive overhaul of the city’s California Science Center, researchers showed that the museum had increased the public’s understanding of and interest in the science covered in the new exhibits. The researchers used public understanding of homeostasis as a conceptual marker to track improved scientific understanding.

SOURCE: Education Week

Links to these reports are provided at edweek.org/links.
“Only recently has the learning theory caught up with those hunches, and now we’re at a place where we really can test design hypotheses based on what we know about the science of learning,” he said.

Ultimately, John H. Falk and Lynn D. Dierking, both professors in free-choice learning at Oregon State University, in Corvallis, hope the field will move toward more “synergy” studies, like Mr. Bell’s longitudinal work, that can explore how people learn science across the formal and informal experiences of their lives.

The Oregon State researchers now are monitoring how children in Portland, Ore., come to learn scientific concepts across the city’s many formal and informal science offerings during a four-year period. Portland provides a perfect microcosm for science learning, Mr. Falk said, because it has one science center, zoo, and public-broadcasting station and a few school districts that will allow the researchers to track individual students over time.

“In order to see real systemic improvement, you have to have a whole greater than the sum of its parts, and now the whole is less than the sum of its parts because there’s no alignment among those pieces,” Mr. Falk said. “We need to develop ways to better integrate practitioners across formal and informal education. We don’t understand how people navigate, make sense of, and make use of the resources in their community.”

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*National Science Foundation, 2004*

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Science-Rich Institutions Provide Venues For Children to Enjoy Exploration

BY ERIK W. ROBELEN
Albuquerque, N.M.

On a recent evening, hundreds of children and their families climbed off school buses and filed into a science center in this city’s historic Old Town neighborhood. The event that drew them, dubbed Family Science Night, was no invitation to hear a lecture on climate change or quantum physics, or to catch a documentary on a giant IMAX screen.

Instead, families from two high-poverty public schools dived into an array of hands-on, interactive exhibits separated into small alcoves in a place aptly named Explora, Spanish for “explore.”

And explore they did. Children got their hands wet—literally—as they manipulated objects in water-based displays in the Water of Life, Life of Water exhibit area. They tapped on a keyboard in the Shapes of Sound section that produced not tones but deep vibrations felt through the bench on which they sat. Over in the Moving Air section, they sliced up paper cups to see how different sizes and shapes would float or twist when placed atop a barrel with a fan inside blowing air toward the ceiling.

“Hey, Daddy, come and look at this!” a young boy blurted out as his paper creation in the Cup Copter exhibit danced in the air. Amid concern that the United States is failing to adequately prepare young people with the knowledge and skills they need to thrive as individuals and keep the nation globally competitive, recognition is growing that the vast American landscape of science-rich institutions can play an important role in addressing the situation.

Science centers and museums, botanical gardens, zoos, aquariums, and natural-history museums, among others, help the public gain a better understanding of science. They also excel at inspiring curiosity and a passion for science-related topics in ways that experts say are too rare.

Such organizations have a big audience. In 2008, a majority of Americans said they had visited an informal science institution such as a zoo or natural-history museum over the past year, according to a report from the National Science Board. About one in four had visited a science center like Explora.

Science centers and museums, in particular, have mushroomed in recent decades, both in the United States and abroad, notes Alan J. Friedman, a former director and chief executive officer of the New York Hall of Science in New York City. Still uncommon in the 1960s, they can be found today in virtually every major metropolitan area of the country—and plenty of smaller communities, too—from Liberty Science Center in Jersey City, N.J., to the Ann Arbor Hands-On Museum in Michigan, to one of the pioneers, the Exploratorium in San Francisco.

The most explosive growth occurred during the 1970s and 1980s, according to Mr. Friedman, who said there are now more than 350 science centers, museums, and related institutions across the nation.

“That’s just astonishing to build cultural institutions at that rate,” he said.

Experts say most science centers and museums, like schools, have a core mission of educating the public, but plenty of big differences exist. Perhaps most obvious, they are “free choice” environments. People can take them or leave them. And visitors decide where to linger and what to ignore. Also, most visitors come only on rare occasions.

The forte of these institutions is highly engaging, and usually hands-on, activities and exhibits that try to bring the “hows” to life with power and immediacy.

INSPIRATIONAL DISCOVERY

Explora, with a stated mission of “creating opportunities for inspirational discovery and the joy of life-long learning through interactive experiences in science, technology, and the arts,” was founded in 1995 as a result of the merger of a small science center and a children’s museum. Financial support comes from several sources, including public dollars from the city and the state, and corporation and foundations.

With about 20,000 square feet of exhibit space, Explora is on the small end among science centers and museums, by venues such as the California Science Center in Los Angeles and the Museum of Science and Industry in Chicago, which, according to its website, is home to some “35,000 artifacts and nearly 14 acres of hands-on exhibits.”

Indeed, while some of these institutions have significant collections, and even house full-fledged natural-history museums, Explora does not.

Its exhibits are essentially learning activities, said Paul Tatter, the associate director.

“The place is organized into clusters of very small exhibits,” he said. “Most of the exhibits are things that you can touch. You can get your arms around them. They fit on table-tops.”

Visitors are invited to investigate with their hands, rather than spend longer and get deeper into each activity, “You have the physical arrangement on the floor to encourage families to stay longer and get deeper into each activity,” he said. “Another is the use of on-floor staff who pose questions more than answer them.”

Like many science centers, Explora has developed a big menu of educational offerings and activities that go beyond the exhibit floor. For example, it runs after-school clubs and summer camps and provides professional development for teachers. It’s established an extensive youth-intern program that provides support and training for high school students who help with various educational programs—and, in some cases, run them—and interact with visitors on the exhibit floor.

Explora also offers a selection of some 200 hourlong, hands-on classes, called “explorations,” both on site and in public schools, community centers, and senior-living facilities, that are run by the center’s staff of full-time educators. The explorations are benchmarked to New Mexico’s state standards in science, math, or art.

Experts say most science centers try to ensure a diverse audience—including minority and low-income families who ordinarily may be less
Barrel blowing air at the Explora in Albuquerque, reaches toward at Tomasita Elementary School.

Lopez noted, and some speak Native American languages.

“We make it a priority to hire people that reflect the community,” he said.

Sara Keeney, the principal of Los Padillas Elementary School, one of the two local public schools invited to Family Science Night in late February, said it’s a big hit.

“This is definitely our biggest family event of the year,” she said. “All the families know about it; they all want to come.”

In December, Explora won a national award from the Institute of Museum and Library Services for what the federal agency described as its creative approach to lifelong learning and its success in reaching out to the community in effective and inventive ways.

Science museum officials around the country say connecting with the community and serving as a resource in multiple ways are high priorities.

“You would be hard-pressed to find museums that only work under their roof,” said Kirsten Ellenbogen, the senior director of lifelong learning at the Science Museum of Minnesota in St. Paul. “Museums are finding more and more ways to make sure they’re fully integrated into their communities and being a resource.”

“Common to all of us is: How do we connect to the communities we serve and add relevance and value?” said Nancy J. Stueber, the president and chief executive officer of the Oregon Museum of Science and Industry, in Portland. “We want to go from being ‘nice’ to being really necessary and seen as integral to advancing STEM learning.”

“A PERENNIAL CHALLENGE”

To be sure, Explora looks a lot different from many science centers and museums, especially the bigger ones. For example, it doesn’t have an IMAX theater, nor does it feature the traveling exhibits popular at many such centers.

One current touring exhibit that’s drawn plaudits is Race: Are We So Different?, put together by the American Anthropological Association in collaboration with the Science Museum of Minnesota. The exhibit, which got support from the National Science Foundation, explores the science, history, and everyday experiences of race in America through interactive exhibits, historical artifacts, photographs, and multimedia presentations. Another recent exhibit, Charlie and Kiwi’s Evolutionary Adventure, which debuted in 2009 at the New York Hall of Science, uses a child-friendly story line to help young people discover the link between dinosaurs and modern birds.

Experts say as the use among science museums is tension between the educational mission and the pressure to bring in revenue.

“This is a perennial challenge for many science centers and museums comes from the formal school system,” he added. “I cherish all the partnerships exist. But a recent report suggests such endeavors have generally failed to ‘institutionalize,’ and experts caution that forming such ties can be tricky.

“The schools have standards and curricula and assessments, and none of them are designed to work with what happens outside of school,” said Mr. Ucko, who also serves on the governing board for the National Assessment of Educational Progress. “They don’t measure a lot of things that really matter to us, like are students interested in science, do they improve their interest over time?”

“We offer an alternative channel,” he added. “I cherish all the ways we are different, and I don’t want to lose those.”
Science Competitions Integrated Into Classroom Curriculum

BY SEAN CAVANAGH

Competition has brought out the best in students at Lyman High School: Styrofoam gliders, designs for airplane wings, and miniature rockets built to soar hundreds of feet in the air.

For teacher Bill Yucuis, it’s about fun, creativity—and day-to-day classroom instruction.

Each year, students at the Longwood, Fla., school, outside Orlando, take part in science and engineering competitions. Some have a large air-and-space potential to inspire teenagers and their peers across the country who sign up for contests designed to ignite science skills. They join thousands of others, as well as after school and on weekends, building the project. Mr. Fletcher ended up creating a new, semesterlong elective class structured around the competition.

Taking part in contests both inside and outside school enables young people to delve deeper into the subject and witness its application.

Students’ positive experiences in the competition played a strong role in administrators’ and teachers’ decision to launch the Engineering Pathways Integrated Curriculum, an academy at Davidson High School in Mobile, Ala.

Seven years ago, teacher Mike Fletcher and school officials arranged to have a group of students participate in the competition, which that year challenged teams to design and build a miniature robot with a fixed base and a movable arm capable of picking up a series of balls. Mr. Fletcher ended up creating a new, semesterlong elective class structured around the competition.

That class had about a dozen students. Over the course of the semester, they spent time in class, as well as after school and on weekends, building the project. Mr. Fletcher graded assignments.

Many science educators and advocates say schools are devoting less time to science, as opposed to reading and math, in the era of the No Child Left Behind Act. As a result, they say, blending competitions into the classroom, or doing anything beyond the required curriculum, can be difficult.

Even so, in some schools, competitions have helped shape lessons and curricula, and even entire programs. For instance, Mr. Blanks, who is also the director of K-12 outreach at the Samuel Ginn College of Engineering at Auburn University, in Alabama, says a number of schools in that state were at least partly influenced to establish academies or programs focused on STEM subjects—science, technology, engineering, and mathematics—after seeing the effects of BEST participation.

“Students’ positive experiences in the competition played a strong role in administrators’ and teachers’ decision to launch the Engineering Pathways Integrated Curriculum, an academy at Davidson High School in Mobile, Ala.”

Bill Yucuis encourages his students at Lyman High School in Longwood, Fla., to participate in science competitions. Seniors, from left, Brandon Kaiser, Spencer Brint, and Robert Kagel work on a miniature rocket for an upcoming contest.

BELOW: Team member Brian Pavelchak, 17, checks the inside integrity of one section of the rocket.
and projects related to building the robot. Despite a few initial hiccups, Mr. Fletcher and school officials were sufficiently impressed with the impact of competition on students to structure more classes around it. Since then, he and other teachers at Davidson High have made the Best competition a major part of several elective STEM-related classes.

BIG PAYOFF

In one of the engineering-focused electives, Mr. Fletcher devotes several weeks to computer-aided design and various types of programming, topics that help students with their Best projects. He and fellow teachers also weave in many STEM concepts, from lessons on mechanics and electricity to digital sound and imaging, that have nothing to do with the competition.

The challenge of competition gives students in his class the sense that they’re taking part in an enjoyable yet high-stakes event, and it emphasizes the importance of understanding each day’s lessons and how to apply them, Mr. Fletcher observed. “They don’t realize at first how great the payoff is in what they’re learning,” he said. “There’s a pride, a motivation, a commitment” among participants, he said, “and a level of retention.”

Mr. Eisenkraft believes many of the teachers who had integrated competitions into their classroom work were elementary or middle school teachers, rather than high school teachers, who generally face more specific curricular demands.

Blending science competitions into the classroom has become easier with the growth of classes focused on intensive scientific research and project-based learning, said Mr. Eisenkraft, a professor of science education at the University of Massachusetts Boston. In many cases, teachers may allow or urge students to take part in competitions as independent projects.

When he speaks to former participants in the ExploraVision contest, Mr. Eisenkraft is often surprised at the numbers of his group don’t want to let each other down. “I tell them, you probably learn more by falling than by succeeding,” the teacher said.

Senior Robert Kagel is working with a group of fellow students on a project for the Team America Rocketry Challenge. They’re charged with building a rocket capable of flying to a height of 750 feet and staying airborne for 40 to 45 seconds—while carrying a single raw egg. It’s supposed to return to the ground with the help of a parachute and the egg intact.

The team started the project at the beginning of the school year; it’s supposed to be completed by the end of April. The students have had to clear numerous hurdles. Designing the rocket on a computer was one thing, he said, but crafting its various components, from the nose cone to the motor, has required continuous readjustments.

Mr. Kagel, who plans to study computer engineering and software at the University of Florida next year, said students are motivated by factors that are stronger than the desire to get good grades. They want a rocket that can hold up to scrutiny in the competition. Members of his group don’t want to let each other down.

“I like winning,” he said. “It does make everybody want to do a lot more. It makes you realize you’re not going to be able to skate by on the work of others. You have to do it.”

SUCCESS BY FAILURE

As the students work through various competitions, Mr. Yucuis gives them individual and team grades, and evaluates them on written and oral reports documenting their work. He does not grade them on how well they fare in the competitions. To do so, he says, would miss the point. “I tell them, you probably learn more by failing than by succeeding,” the teacher said.

Mr. Yucuis allows his students to choose from a number of competitions. They are taking part this year in the Internet Science and Technology Fair, the Team America Rocketry Challenge, and the Real World Design Challenge, among others. His freshmen also take part in the No Boundaries National Competition, directed by the National Aeronautics and Space Administration and USA Today Education, a developer of school programs owned by the national newspaper. The competition asks student teams to devise strategies for marketing STEM careers, such as those at the federal space agency, to teenagers.

Mr. Fletcher allows his students to develop projects related to building the robot. Despite a few initial hiccups, Mr. Fletcher and school officials were sufficiently impressed with the impact of competition on students to structure more classes around it. Since then, he and other teachers at Davidson High have made the Best competition a major part of several elective STEM-related classes.

“We know high-quality after-school and summer learning programs could benefit more children. A new three-part report, Hours of Opportunity, offers ideas for making that a reality. You’ll find all three volumes online as free downloads, along with other research on out-of-school time (OST) and summer learning, educational leadership and arts education.
Games and Simulations Draw Children Into New Vistas for Accessing Science

By Katie Ash

Want to know what it’s like to stalk elk, or a mate, from the vantage point of a wild animal? Educators at the Minnesota Zoo, located in a suburb south of the Twin Cities, created just such an online game a few years ago that has proved immensely popular—and educational. Called WolfQuest, it allows players to learn about wolf ecology by exploring Yellowstone National Park as that creature. “We’ve always been interested in reaching out beyond our walls, educating people no matter where they are, and for us, we felt like the Internet was a great tool to provide access to educational resources and connect with kids where they’re at,” said Grant Spickelmier, the zoo’s assistant director of education. High-tech games and simulations are second nature to today’s students. For educators and researchers, those virtual worlds offer the freedom to create innovative digital tools that tap into children’s motivation outside the classroom and generate excitement about science. As prominent an authority as the National Research Council has extolled the potential of computer games and simulations to better engage young people in science learning and promote a deeper understanding of and facility with the subject. “They enable learners to see and interact with representations of natural phenomena that would otherwise be impossible to observe—a process that helps them to formulate scientifically correct explanations for these phenomena,” the NRC said in a recent report. “Simulations and games can motivate learners with challenges and rapid feedback and tailor instruction to individual learners’ needs and interests.” The Minnesota Zoo’s evaluation of its own game found “that kids were learning the science, were more interested in wolves, and were more interested in science as a result of playing the game,” Mr. Spickelmier said. In WolfQuest, players learn about wolves by embarking on missions that a wolf would typically undergo, such as feeding and taking care of pups. Players take the role of the animal and are presented with response options when they encounter certain situations, such as the presence of other wolves. For example, when interacting with a potential mate, players can choose to leave the interaction, take a defensive stance, play, or show affection. The game was created primarily for children to access on their home computers, the zoo has increasingly been contacted by teachers interested in incorporating the game into their classrooms. Mr. Spickelmier said the zoo has since crafted curricular materials to help connect the game with what students are learning in class, he said.

Inside a Virtual World

Whyville, a virtual-learning environment for children started in 1999, was created by James Bower, the chief executive officer and founder of Whyville.net. “Our original intent was to build games and network-based worlds for use in schools and out of schools and connecting the two,” he said. “And we are just now crossing that threshold, which is being accelerated by the fact that states are deciding to go with digital curriculum.” Unlike games, Whyville is an unstructured online environment where players participate in activities to earn “clams”—the form of currency in Whyville. Through partnerships with companies and organizations, such as Dell, Toyota, and NASA, players can explore a host of activities. For example, the infectious “Why-Pox” was introduced into Whyville, prompting a series of responses from its residents, who covered the outbreak in the Whyville Times, the player-organized newspaper. “They didn’t know it was coming,” said Mr. Bower, the chief executive officer of Numedeon Inc., which runs Whyville. “They just started breaking out.” The U.S. Centers for Disease Control and Prevention later came in and “vaccinated” players against the disease.

The Texas Workforce Commission has also partnered with the virtual world to finance a bioplex “where kids actually do research on how you develop antibodies, different types of viruses, and how they work,” Mr. Bower said. The power of Whyville comes from the children’s interest in exploring and asking questions, he said. “What underlies the whole initiative [of the center] is really paying attention to the dynamics of what motivates students’ engagement,” Mr. Bower said. “It’s not that play is fun and entertaining and slightly humorous is really important to creating the right kind of positive emotional residue toward science learning. Particularly in this day of high-stakes accountability, it’s the joy and passion and deep motivation for learning that we’ve lost.”
Independent Play Fosters Discovery In Young Children

BY MARY-ELLEN PHELPS DEILY

Over and over, experts say, it comes back to this: Young children are natural scientists. They ask questions, they explore, they touch things and push things, and they try to figure out what combinations have the best chance of working for them—even if the subject of their inquiries is just a toy.

So, how does one nurture these little scientists? In some ways, it’s easy. “When children are doing things like playing and exploring, they’re actually doing science,” said Alison Gopnik, a researcher at the University of California, Berkeley, who has written books on young minds, including *The Philosophical Baby.*

What preschoolers need, she continued, is independent play, not lectures on science. “You pay attention to what they’re interested in, you follow their lead,” Ms. Gopnik said. “Start out from the questions the children are asking you.”

One key is to avoid squelching youthful curiosity unconsciously. Ms. Gopnik pointed to work by Massachusetts Institute of Technology researcher Laura Schulz and colleagues. In one experiment, they offered young children a box with many buttons on it. With some children, the adults acted as if they didn’t know what the buttons did; they pushed one that made the box squeak, but didn’t let on that they knew how the squeak came about. However, the adults showed other children not only how one button on the box worked, but also pointed out that pushing the button in question resulted in a noise.

In Hartford, Conn., the city’s librarians know that, and they work hard to reach children through a mix of seminal, material-based programming and informal guidance. The libraries there are the recipients of a grant from the Hartford Foundation for Public Giving that, along with state and city council funds, supports special programming for preschoolers in science and math.

Working with parents, children, teachers, and child-care providers, librarians in the city now provide material-based and guided activities for children in the grant program, as well as training for parents on how to encourage children’s curiosity from a young age.

“The kids were gobbling it up,” said Ms. Hamid, who is the assistant youth-services librarian in the Hartford Library’s Barbour branch. When she’s working with young children, she said, she wants to help them cultivate their questioning minds. Comparing things and noticing differences—What color is this? Will it sink? Will it float? Is it hard, or is it soft?—encourages curiosity, she said. “Hands-on, tactile learning is also critical.”

“Innovation is the key for anything. ... Out and about, in the house, even in the kitchen,” Ms. Hamid said. The Connecticut Science Center, also in Hartford, is working with the library on the grant project. The center includes a KidSpace gallery built specifically for children age 6 and younger. Thanks to the grant, the center can work with many parents and young children on special projects that might not otherwise visit; it even provides free transportation and translation services for a parent-child day at the museum. That is crucial in a city where, in 2009, 39 percent of the children were living in poverty, according to Census data.

For all age groups, the center’s goal is “to enable all of our visitors to have conversations about our exhibits,” said Holly Harrick, the center’s education director. With parents of young children, “we want them to help the children observe ... and help them formulate questions.” She added: “Young children are naturally curious, so we really build on that.”

That means hands-on experimenting and touching and raising open-ended questions. Preschoolers “need play, they need to interact with what’s in the box,” Ms. Harrick said. In the science center’s KidSpace, that might mean tossing a ball into a funnel and then watching the path it takes as the funnel—which functions like a cyclone—sends the ball through clear plastic tubes.

Water play, Ms. Harrick added, “is wonderful” and a natural with small children, and questions such as “What did you notice? What do you wonder?” are great queries to pose to a budding scientist.

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The increased national interest in science learning and achievement means that some places are putting more emphasis on formal science learning for young children. On that note, Ingrid Chalulfour and Karen Worth of the Education Development Center, a research organization based in Newton, Mass., developed the “Young Scientists” series for preschool classrooms with support from the National Science Foundation. The guides focus on teaching children about the natural world and developing their knowledge of life science concepts through observing nature, building structures, and water play.

Today, an EDC team is studying ways to encourage teachers to take a more inquiry-based approach, said Nancy Clark-Chiarelli, a principal investigator with the team. Teachers with knowledge about the subject matter can ask open-ended questions and foster curiosity, which helps children find deeper meaning in their classroom science experiences, she said.

In addition, the EDC team developed Young Scientists, a professional-development program that builds on the Young Scientists series.
National Science Foundation Seen As Leader in Advancing Informal Learning

BY ERIK W. ROBELEN

The National Science Foundation, widely recognized as the leader in advancing informal learning, has played a key role in the last decade in supporting a variety of initiatives that aim to enhance public understanding of science. The foundation's efforts have been fueled by the federal Informal Science Education program, which provides grants specifically aimed at advancing informal science education venues.

The agency, he said, tries to have a broad reach in terms of content, audience, and the nature of the learning experience. “In all of this, we are trying to promote successful interactions with the public and improvements in how to do that,” Mr. DeSena said, adding that “educational innovation is a key element for any award that we make.”

Martin Storksdieck, the director of the Board on Science Education at the National Academies, said he appreciates the way the NSF has pushed grant applicants. “It doesn’t simply underline good ideas, he said; rather, it insists that any new grant support an idea that somehow advances the field and moves beyond current practices.”

“I like the idea of the NSF saying: Make the case for me why this is important. Build on what’s been done before. Create partnerships that work, and ask yourself if what you’ve created is effective,” Mr. Storksdieck said. “The culture of that type of thinking has been created by NSF.”

Observers note that the agency’s work in informal science has evolved over time, and that over the past decade or so, it has ratcheted up requirements for evaluating the impact of projects. Sue Allen, the director of the NSF’s division of learning in formal and informal settings, said she sees a number of important changes over time in the agency’s work. “What it takes to get funded gets harder and harder,” she said. “NSF has been moving the bar higher in terms of evaluation, disseminating and learning from prior work, and connecting with other research areas and traditions.”

She added: “We’re pushing for a more compelling and nuanced rationale for what [applicants] do.”

The National Science Foundation supports a wide range of initiatives through its Informal Science Education program, distributing about $65 million in grants each year. Among the new or continued grants announced over the past two years are:

- **Go Botany: Integrated Tools to Advance Botanical Learning**
  - $1.63 million
  - Integrates Web tools and mobile-communication devices to facilitate learning about botany and plant conservation, with a focus on native and naturalized plants in New England

- **Gulf Oil Spill Disaster Coverage**
  - $199,000
  - Supports National Geographic television’s creation of a multimedia media effort to communicate the scientific and engineering stories unfolding in the Gulf region as a result of the major oil spill in 2010

- **Making Space Social: Exploring the Educational Potential of the Facebook Social Network**
  - $594,000
  - Underwrites a pilot investigation by the Space Science Institute on the use and effectiveness of STEM-related games within contemporary Web-based, multiplayer social-networking platforms.

The NSF first launched a program for informal science learning in the 1950s. At the time, it was called Public Understanding of Science. In 1983, that initiative was replaced by the Informal Science Education program, which is the main but not only source of funding in this domain. The agency provides about $65 million a year through the program, which supports a wide variety of activities, including the production of films and community projects, traveling museum exhibits, after-school initiatives, and cyber-enabled learning. Of that amount, about $25 million is available for new awards, while most of the rest goes toward the continuation of prior grant commitments. The agency requires an evaluation to assess impact. The science foundation also provides grants specifically for research and has helped support the establishment of organizations such as the Center for Advancement of Informal Science Education, a partnership of several institutions that aims to improve informal-science-education practice, document evidence of its impact, and communicate the contributions of the field.

The emphasis of the NSF’s Informal Science Education program is learning outside formal school settings. “The way we describe informal science education is ... anywhere, anytime, lifelong learning,” said Alphonse T. DeSena, a program director at the NSF. “Sometimes it happens in school, but it’s not part of the curriculum.”

The agency, he said, tries to have a broad reach in terms of content, audience, and the nature of the learning experience. “In all of this, we are trying to promote successful interactions with the public and improvements in how to do that,” Mr. DeSena said, adding that “educational innovation is a key element for any award that we make.”

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Environmental Issues Inspire Children to Dig Into Science

BY CARALEE ADAMS

Students in the science club at Pickens Middle School in Pickens, S.C., had been planning a trip to swim with manatees in Florida when news of the oil spill in the Gulf of Mexico hit last year. “I was kind of worried about the manatees,” said 12-year-old Alex Womack, who had been studying the marine mammals in the club after school and in the summer. “I thought the oil might hurt them and make them extinct.”

In February, 54 students from the school took that trip, traveling 12 hours by bus to see the creatures in their winter-migration home of Crystal River, north of Tampa, Fla.

“You actually got to see how pretty they are, and you feel more for them and how much they are endangered,” said Alex, an aspiring marine biologist who said the manatees looked like a cross between a dolphin and a cow and felt like seaweed when she petted one. “It made me like science a whole lot more.”

That’s just why science teacher Susan Hilyer, the faculty adviser to the science club, along with two other teachers—Laura Anderson and Louise Hope—persuaded the 16,000-student Pickens school district to overcome its concern about exposing children to water and wild animals. They knew the experience would be more powerful than a classroom lesson.

“There is no comparison to just being outside and in the midst of it,” said Ms. Hilyer, adding that the experience doesn’t have to be as extreme as swimming with manatees. “You can get that same ‘wow’ just digging in dead logs with little shovels. It’s real. If it’s not real, they don’t care.”

Informal science programs that focus on the environment often hook young people because they are about issues that really matter in their lives—the quality of the air and water and the well-being of animals. If it’s relevant, they want to learn. And often, children are motivated, in response, to make a difference by cleaning up a stream, starting a recycling program, or advocating eco-friendly policies.

“It’s that application to real-life experiences that brings environmental education alive,” said Brian Day, the executive director of the North American Association for Environmental Education, a nonprofit group in Washington. “It turns kids on if they take an action component and can make an improvement in their school community or backyard. Then all that education has a focus and a purpose.”

And an after-school or summer science experience offers time and flexibility for children to explore and follow their own interests—without the stress of grades.
Lucy Friedman, the president of The After-School Corp., or TASC, in New York City. “Science and after-school programs have such great synergy. Kids feel it’s OK to take a risk,” she said. “Sometimes there isn’t always a right answer.”

When TASC does science training for after-school staff members, it emphasizes that the leader is merely guiding the process. “There is a tendency of adults to explain to kids what happens,” said Ms. Friedman. “It’s much more powerful when kids discover on their own and make some of the mistakes.”

Some TASC programs take students to New York’s Coney Island to measure the temperature of the water and sand. “All of a sudden, the beach they connect with fun becomes a learning environment,” Ms. Friedman said.

MAKING IT REAL

In California, water is the “new gold,” because it’s a limited resource in great demand, so it’s important for children to understand it, said Marianne Bird, the youth-development adviser for the Sacramento County 4-H Water Wizards, a 12-week after-school program for grades 4-6.

“Young people need to be aware that there is no new water,” she said. “Water is always involved in a system, and they are in the system.”

The nearly 500 children who take part in the program learn about the water cycle, the watershed, and wetlands, and they conduct experiments. A service-learning piece and a field trip to a water education center where Sacramento’s water is held are also part of the program.

Being outside and part of a larger environmental project is a big motivator for young people, said Rick Bonney, the director of the Cornell University Laboratory of Ornithology program. Many students participate in the lab’s Great Backyard Bird Count and BirdSleuth as campers or in an after-school setting. They learn the protocol of identifying birds and collecting data.

“This is authentic, real science. We are answering questions whose answers aren’t known,” Mr. Bonney said.

Another citizen-science initiative, the Monarch Larva Monitoring Project at the University of Minnesota-Twin Cities, engages middle schoolers. In the summer, groups track monarch butterflies once a week to see how they change over time, said Karen Oberhauser, a professor of fisheries, wildlife, and conservation biology.

The children all do independent research questions and set up experiments, Ms. Oberhauser said. One student recorded the fate of 60 larvae that she tied to various locations to study monarch predators. Another studied the timing of the arrival of monarchs, who only lay eggs on milkweed, vs. the availability of that milkweed for their larvae to eat.

“In the end, when we gather around the picnic table, I love hearing them come up with questions. They’re so focused,” Ms. Oberhauser said.

Once, students observed butterflies mating, which triggered a discussion. “In school, it would be a reason to be giggling and not pay attention to the science of it,” she said. “But they took it very seriously.”

EXPOSURE TO NATURE

The St. Louis Science Center takes small groups of teenagers from its Youth Exploring Science program to a pond at dusk armed with flashlights to sit still, listen, and record frog calls. Their information goes into a larger database as part of a project examining the impact of climate change on frog populations.

By participating, the youths begin to understand the process of science better, said Kerri Steverson, the senior educator in charge of the Communicating Climate Change program. “Science isn’t something people just write about,” she said. “They learn to follow strict rules and understand the protocol.”

Over time, those inner-city students—many of whom don’t have much exposure to nature—become more comfortable with animals and stomping around in the mud.

Likewise, at New York’s Captain Manuel Rivera Public School, in the Bronx, many K-8 children don’t have much of an opportunity to connect with the outdoors. The after-school program Frontiers in Urban Science Exploration, sponsored by TASC and coordinated by the Committee for Hispanic Children and Families, is designed to provide that link with trips to zoos, parks, and rivers to explore natural resources, said Helena Yordan, the site coordinator for the committee. Through the inquiry-based, hands-on activities, children get excited about learning and the scientific process. “Science is for everyone. That’s our slogan,” said Ms. Yordan.

In the program’s informal setting, leaders can talk about careers in science. Ms. Yordan also keeps teachers informed about the projects to connect the after-school work with what’s happening in the classroom.

Contests such as the Siemens We Can Change the World Challenge give children a chance to create an environmental solution and compete for prizes.

Last year, 6th graders Rani Iyer and Isha Laad, both living in Lexington, Mass., at the time, spent 200 hours each working on an entry for the contest. Concerned about the harmful impact of chemicals used in dry cleaning, they tested a wet-cleaning process and worked to persuade businesses to switch to a more eco-friendly process.

The girls did testing in nearby college labs, where they used chemicals they wouldn’t have had access to at school. “No one was telling us what to do,” said Rani, 13, who has since moved to West Lafayette, Ind. “It seemed like it meant more than what we do in school, where the teacher knows the outcome of the experiment. We don’t know what it is.”

The team was a finalist, and each girl won a $5,000 savings bond and a pocket camera. Rani is considering entering the contest again and perhaps pursuing a career in science or math.
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